

Chapter 2

Preliminary Discussion on the TTC and Management of Commercial Space in China

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2.1 Introduction

To the commercial space, there is no unified definition at home and abroad. It is generally accepted that commercial space refers to the use of business, the market model to develop, operate space program, and according to the market rules to carry out space activities [1, 2]. The space programme includes satellite (including spacecraft) services, satellite manufacturing, ground equipment manufacturing, and launching services [3]. The Space activities include commercial rockets manufacturing, commercial satellites manufacturing, commercial launching, commercial space TTC [4]. In recent years, international commercial space improves rapidly, a large number of emerging space enterprises to participate in the development of commercial space, business covers the whole space industry chain, the development of aerospace industry injects new life into the world [5]. Taking The United States for example [6, 7], a number of commercial aerospace companies emerged, including Space Imaging, Orbimage, OneWeb, O3B, which domained in commercial satellites application, and SpaceX, Blue Origin, which engaged in commercial rockets manufacture, commercial satellites manufacture. At present, commercial space in Chinese has just started, which was still in the stage of exploration, a number of commercial aerospace companies emerged as well [8, 9], such as Changchun optical satellite technology LTD., Four-dimensional remote company LTD., which engaged in commercial satellite manufacturing and commercial satellite application, 0–1 space technology LTD., which engaged in commercial rocket manufacturing.

Space TTC mainly completes the rockets, or the satellites tracking, telemetry, remote control and other tasks, which takes the rocket flight state in control, as well as orbit survey and determination of on-orbit satellites, management of running

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state, payload data reception and distribution. Space TTC provides indispensable support for launching and recovery, in-orbit application of satellites [10]. In order to satisfy space engineering of the communication satellites, resource satellites, navigation satellites, ocean satellites, manned space, China has built the ultrashort band, C band and S band space TTC network, which are in appropriate scale, reasonable layout, fully function. To the rise and development of the commercial space of our country in future, space TTC system in China will adjust the service mode to meet the needs of the new task, and provide a more efficient and convenient TTC support service.

Commercial space is the important developing direction of the aerospace industry in the future. This paper analyzes the enlightenment of the foreign commercial space and commercial space TTC to our country in future, and for some of the new commercial aerospace TTC and management questions have carried on the preliminary discussion.

2.2 The Current Developing Situation of Commercial Space and Commercial Aerospace TTC at Home and Abroad

2.2.1 The Current Developing Situation of Commercial Space at Home and Abroad

The United States is the first and the most successful country in the development of Commercial space, who draws up and promulgates a series of relevant laws, regulations and policies, to encourage and support the development of the commercial space, and provide legal protection for commercial space activities. From 1984 to 2015, the United States has promulgated more than 20 laws, regulations and policies, covering space policy, space launch, manned space, satellite communications, satellite navigation, satellite remote sensing, etc. Under the stimulus of national policy, the commercial space industry chain all full blossom, especially in the satellite remote sensing application, satellite communication network and orbital transportation.

Space imaging company, which separated from Lockheed Corporation in October 1994, aimed at making the world's most advanced earth observation technology commercialized, to provide users around the world digital earth information products and services. IKONOS-2 satellite launch success and realize the business operation on September 24, 1999, begun to provide more than 1 and 4 m panchromatic image spectral resolution. This is the world's first commercial operation of high resolution remote sensing satellite, since then opened up a new era of civil high resolution earth observation. The company also has sole global franchise of "Landsat digital image".

Orbit imaging company was founded in November 1993, which is in the domain of design, construction, management and sales of a wide range of products and services related to the space. The company currently has three OrbView satellite, which have sold in the United States the rights of the other satellite systems in remote sensing images, including Canada RADARSAT-1, 2 of synthetic aperture radar platform, and SPIN-2 satellite of Russia. In 2005, orbital imaging company acquired the Space Image's assets [11].

One web company was founded in 2012, is committed to launch small satellites in low earth orbit to form a communication network. 648 small satellites plans to launch, whose altitude is about 200–2000 km, complete the Internet coverage of local area, and provide about 50 Mbps internet speed. OneWeb company plans to launch its first satellite in 2017.

Spire company was founded in 2013 [12], is committed to deploy meteorological satellite network. Spire plans to launch 100 satellites in MEO, by measuring the GPS satellite signal to obtain atmospheric meteorological data, such as temperature, pressure and humidity.

Space exploration technology company (SpaceX) in the United States was founded in 2002 [13], is committed to developing recyclable rocket, and manned spacecraft. Currently SpaceX develops partly reusable falcon 1 and falcon 9 rockets, and the sequence of Dragon spacecraft. In October 2012, the dragon spacecraft was raised to send the goods to the international space station. In March 2015, the falcon 9 rocket will be the first all-electric communications satellite into orbit. In December 2015, falcon 9 rocket goes up and 1st stage recoveries successfully. In April 2016, 1st stage of falcon 9 rocket successfully landed on a maritime unmanned ship.

Blue origin company was founded in 2000 [14], set up by the world's largest online retailer amazon, its main products include engine and suborbital rocket. In November 2015, the orbiter launch New Shepard to an altitude of 100 km, then the rocket intact landing to the predetermined ground position, realized the reusable suborbital vehicle.

Other countries such as Canada, Argentina's aerospace business company has its own satellite launch and operation plan. Canada SkyboxImaging company was founded in 2009, mainly to provide real-time satellite imaging services platform, image accuracy is lower than 1 m. As of March 2014, a total of 24 small satellite SkySat in orbit. Argentina Satellogic company was founded in 2010, mainly to provide real-time earth image data. As of June 2014, three LEO satellites are running in orbit, which will increase to 300 satellites in future. Europe also increased support for the development of commercial space through legislation and policy. In December 2015, the British issued "the national space policy," [15] aimed to become center of Europe commercial space, and occupy a larger share of space market in the world.

At present, the traditional plan mode of "national investment, enterprise development" is predominated in the aerospace industry, the commercial space has just started in China. In recent years, the Chinese government encourages private companies to get into space business, especially when the time the Belt and Road

initiative was put forward since September 2013. The development of aerospace industry especially commercial space industry, brings better service to the national strategy. In October 2014, prime minister Li Keqiang, at a state council executive meeting, proposed to gradually guide the folk capital to participate in the national civil space facilities. In November 2014, the state council announced the 60 document, more specifically to encourage private capital into the spatial domain. In October 2015, the medium and long-term plan for the national civil space infrastructure (2015–2025) is put forward [16], to encourage military and civilian integrated capital into space, base areas are opened by space military-into-civilian as start. Under the encouragement of national policy, lots of innovative enterprises have sprung up which focused on commercial rockets manufacture, or commercial satellites manufacture.

Changchun optical satellite technology LTD., established in December 2014 [17], is funded by Changchun Optical Institute and other shareholders, which focused on manufacturing commercial remote sensing satellites. Company plans to launch 60 video satellites before 2020, and 138 video satellites before 2030.

Four-dimensional remote company was established in September 2015 [18], funded by the aerospace science and technology group, will provide global users with high spatial resolution, high temporal resolution, high spectral observation ability of all-weather of remote sensing for earth observation data services. Company plans to be completed around 2022 by 16, 0.5 m resolution optical satellites, 4 high-end optical satellites, 4 microwave satellites, and some video, hyperspectral satellites.

0–1 space technology LTD., was established in August 2015 [19], is funded by private shareholders as a commercial rocket manufacturing company. The company aims to develop, design, and final assembly of low-cost small vehicles. Its first flight will be carried out in 2018.

2.2.2 The Current Developing Situation of Commercial Space TTC at Home and Abroad

At present, space TTC resources, including ground station and control center, have three kinds of subordinate relations [20, 21]:

1. as a national infrastructure, directly by the government and/or military management, such as the United States NASA's tracking and data network (STDN), the U.S. air force satellite control network (AFCSN) acquired, ESA TTC network, the Russian state TTC network.
2. ground stations networking, belongs to an international organization, such as International Maritime Satellite Organization is a global mobile satellite communication of intergovernmental cooperation mechanism, namely the international mobile satellite organization, which domestic habitually call it maritime satellite for short. Maritime satellite organization reformed as an international

business company in 1999, namely the international mobile satellite. Maritime satellite organization has two control center, with main stations in City Road, backup stations in Boreham wood, and eight stations distributed in Italy, China, Canada, New Zealand, the Netherlands, Norway, Russia, the United States. So far, maritime satellite organization manages 11 satellites.

3. a large company has a corresponding ground station and control center, is divided into two kinds, one kind is that the company has its own satellite, established corresponding ground station network, such as China Fengyun, China Satcom. The control center of China Fengyun was built on the National Weather Service, which takes control of four stations in Beijing, Guangzhou, Urumqi and Australia, and is in charge of 5 low-earth orbit and geostationary orbit satellites control. China Satcom operation control center was built in the northwest of Beijing, which takes control of four stations such as Beijing, Hong Kong, Chengdu, and is in charge of 6 geosynchronous orbit satellites. This kind of networks support only professional satellite application, do not support other civilian satellite TTC. Satellite application oriented specific service objects, which belongs to space commercialization. Another kind is that to establish a station network, which provides the service for all satellites, belongs to commercial space TTC. At present, some of the domestic commercial company plans to build its own space TTC network. Some company has certain influence on the international commercial TTC, such as PrioraNet global station network of Sweden Space (Swedish Space Corporation, SSC) and Norway's Satellite service company (Kongsberg Satellite Services, KSAT).

PrioraNet global station network of Swedish Space company(SSC) is composed of the network management center (NMC) [22], SSC's own core station and cooperative stations all over the world with strategic position. The ground stations of SSC are divided into two kinds, one kind is that belongs to Sweden space center, and another kind is cooperation with international partners, who provide C/S, L, X, UHL spectrum TTC services. The NMC is a distributed system, which located in Newport Beach, California, Kiruna, Sweden and Pennsylvania Horsham, which can provide users with a single point of interface in the global earth station. In the whole stages of missions, spacecraft and network operators to provide services and support round the clock. 10 its own core stations, and 6 cooperative stations, distributed in Sweden, Italy, Germany, Australia, Canada, the United States, Chile, India, Mauritius, South Africa, Antarctica, and other countries and regions. PrioraNet network provides reliable solutions for global satellite communication and operation, which provides the services including task management services, mission control services, TT&C services, load data retrieval services. The major customers of PrioraNet global station network include Boeing satellite systems corporation, China aerospace science and technology group LTD., China resources satellite application center, California's space agency, China satellite TTC systems, the geographic eye technology, geographic information from Thailand and space agency, NASA, Taiwan space center, etc. In 2009, the Universal Space Network (USN) bought out by SSC, USN company adopted the mode of commercial

operation to provide satellite operations (including real-time telemetry, tracking, and commanding) services.

Space TTC network of Norway's Kongsberg Satellite Services (KSAT) is composed of the Tromsø Network Operations Centre(TNOC) and four ground stations [23]. TNOC takes control of Tromsø satellite ground stations and TT&C antenna system of Svalbard, and works closely with the owner and the operator of satellite, which is responsible for all operations. Four stations include Svalbard ground station, Tromsø ground station, Grimstad and TrollSat ground stations. This network provides TT&C and data services mainly for polar orbit satellite, which includes telemetry, TTC, TTC support for sounding rockets, launch and early orbit (LEOP) TTC support, Global data dump or on-orbit support. The main client of the network includes: NASA, ESA, NOAA, IPO, JAXA, DigitalGlobe and so on.

2.3 Enlightenment of Commercial Space TTC to Our Country

2.3.1 The General Trend of TTC and Management Development is Diversified

From the perspective of the current foreign developing situation, the coexistence and coordinated development of military/civil space TTC, commercial space TTC is the trend of the times. Military/civil space TTC major services military and civilian satellites, which makes more services for commercial satellites when redundancy. For example, SpaceX's "the falcon 9" tipped the "dragon" spacecraft from military launch pad in Florida, its launching TTC is operated by AFCSN 45th space operation team, "dragon" spacecraft entered orbit outside the international space station a mile run by ferry companies themselves, into the international space station within a mile of the approximation, docking, and out of control was conducted by NASA. Commercial space TTC services mainly for commercial satellites, which can provide service for worldwide space users, either through business model to make its own global ground stations networking, or through business model to cooperate with foreign ground stations by networking operation. Such as SSC's PrioraNet global ground station network, Norway's KSAT provide TTC supports for lots of global commercial satellites.

Both military/civil space TTC and commercial space TTC, the management mode is just the same, composed of mission center and ground stations. Due to the earth synchronous orbit satellite visible to a ground station for 24 h, one single station can be used to manage the satellite. For commercial geosynchronous orbit satellites, commercial companies can accomplish TTC in its own application business simultaneously. Because of the influence of the earth curvature, to meet TTC requirements of the full range in low earth orbit satellites or rockets, multiple ground stations must be distributed in different locations connected in the network

to relay TTC task. The network can be under a TTC system of multiple ground stations, or under different TTC systems. For commercial satellites in LEO or MEO orbit, the investment of a commercial company self-built the network is too high, two more reasonable ways are: 1. to purchase commercial company’s TTC service, with global TTC ability; 2. to use of national support network to complete the TTC.

2.3.2 *It is Imperative to Moderate Encourage the Development of Commercial Space TTC*

At present, the main TTC mode of commercial companies abroad [24–28] are shown in Table 2.1.

From present developing situation foreign, there are two main types of commercial space TTC mode: 1. building their own site, such as the United States’s Orbimage, One Web, Spire. 2. purchase a TTC service or completely entrust other units to complete the TTC, Such as launching and orbiting TTC of spaceX, launching TTC of Blue Origin. From the situation abroad, orbiting TTC mainly be completed by satellite users or satellite manufacturers. For our country, space industry is open to the commercial capital, inevitably space TTC must be open to commercial capital. If the developing pattern of commercial space TTC looks abroad, on the one hand, the cost of TTC services will be decreased, the efficiency of TTC services will be improved, on the other hand, it helps to better participate in international competition, or better international cooperation.

From domestic developing situation, the rise of the future commercial space can lead to the development of commercial satellite in explosive growth momentum.

Table 2.1 The main TTC mode of commercial companies abroad

Commercial companies	Main business	TTC mode
Orbimage	Commercial remote sensing satellite application service	Stations built by self, data processing center and more than 10 stations, which can control satellites,and receive remote sensing data
OneWeb	Internet satellite application service	Stations built by self, plans to build lots of Ku band stations
Spire	Meteorologic satellite application service	20 stations built by self, to receive satellite data
SpaceX	Orbital transportation service	Control center built by self, purchase TTC service launching TTC bought by military service, on orbit running controlled by self and by NASA, on orbit running bought by commercial service
Blue origin	Suborbital transportation service	Launching TTC bought by military service, other is unknown

Future commercial space is given priority to with the application of small satellite constellation, small satellite constellation control has the following characteristics: 1. large number of on-orbit space targets, with wide spatial distribution. Satellites inbound or outbound frequently, number of satellites have short interval transit time, requiring a close “all-weather” TTC. 2. a satellite orbit, such as satellite remote sensing application are mainly concentrated in orbit height 500–800 km sun-synchronous orbit, large number of targets inbound or outbound thick and fast, required to provide multiple targets for TTC service simultaneously. Existing TTC resources are close to saturation, which appropriately support only a part of commercial space TTC requirements. It is imperative to moderate encourage the development of commercial space TTC.

2.4 Preliminary Discussion on the TTC and Management of Commercial Space in China

2.4.1 Strengthen Space Legislation

Our country should make space rules at national level, and industry standard level, to regulate commercial behavior and space activities in commercial space and commercial space TTC [29], and to promote the orderly development of commercial space and commercial space TTC. Space activities should be under the legal framework, otherwise may affect subsequent commercial space development. Commercial space needs more space under the rule of law. Legislations should be put out to regulate specifications and requirements of military space, civil space and commercial space activities in our country, in order to ensure the orderly development of aerospace industry (including TTC). Through space legislation, commercial space market access or exit mechanism, fair competition mechanism, insurance and compensation mechanism, safety supervision mechanism, etc. are established, to create an orderly, healthy competition market environment.

2.4.2 Explore the New Commercial Space TTC and Management Model

Commercial company is Encouraged to build mission center, or stations, which protect commercial satellite orbit control, and actively explore the new commercial aerospace TTC management model.

1. support external connection to satellite mission center

External satellite mission center is supported to run with existing satellite TTC center, Satellite TTC center transparently send control instructions to commercial

space TTC ground station by satellite mission center. The health status of commercial satellites can be directly sent to satellite TTC center. The commercial satellite TTC process and interface must be standardized, to support the external network.

2. strengthen international cooperation of commercial space TTC ground station

Commercial space TTC builds their own station at home, makes international cooperation overseas. Domestic and overseas stations can interact with each other.

2.4.3 Enhance the Management of Commercial Satellite Services

For all of the satellites, including commercial satellites, strengthen policy management, good services, on the one hand, due to protect national security need to consider, on the other hand due to ensure the safety of commercial satellite and other satellite orbit. On-orbit satellite management services shall include the following aspects:

1. the frequency management services

Satellite frequency become important strategic resources. To top the satellite TTC, digital frequency resources unified planning and design, harmonious and unified management, in order to prevent the on-orbit satellite radio interference between each other.

2. the orbital resource management services [30]

Satellite orbital gradually become scarce strategic resources. For satellite orbital resources unified management, according to the national security, different requirements in terms of hierarchy, such as the national economy needs conflict level according to the distribution of rail.

3. catalogue management services

With the increasing of space target quantity, space target catalog, collision warning is becoming more and more important. All satellites are unified to detect, track and recognise, the trajectory characteristics, geometric characteristics and physical properties of space target is unified for catalogue management, and to provide commercial launch, commercial satellite application collision warning service.

4. launch and recovery services

Satellites enter into space, and return from space to ground, space safety is a matter of territory. The satellite launch and recovery should be unified management services, highlighting the launch and recovery of safety design.

2.5 Conclusion

Commercial space technology development derived from military space, civil space, but with different development model. The arrival of the commercial space puts forward the new requirements, which requires that we should not only by law of space, space concept, and also inject new ideas, new management idea. In this paper, the parts of the commercial space TTC management questions have carried on the preliminary analysis and discussion, the more problems, more in-depth analysis needs to be further discussed in accordance with the commercial space development and progress in China.

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